Samarawickrama, Sumanthri, et al (eds), 2019, "Re-evaluating Space across disciplines": *Proceedings of the 12th International Conference of Faculty of Architecture Research Unit (FARU), University of Moratuwa, Sri Lanka, December 03, 2019 Colombo* pp. 63–69. ©

INVESTIGATING THE IMPACT OF NON-LOAD BEARING (NLB) WALLS ON THE BUILT-UP AREA AND DEAD LOAD IN MULTI-STOREYED RESIDENTIAL BUILDINGS

RASTOGI ABHIJIT[1] & PAUL VIRENDRA KUMAR[2]
[1, 2]Department of Building Engineering and Management, School of Planning and Architecture, New Delhi, India
[1]arabhijit@spa.ac.in, [2]vk.paul@spa.ac.in

Abstract
The Indian housing sector is transforming rapidly. Over the last decade, change is noticeable because we transformed from multifamily independent houses to multi-storeyed dwelling units. There are several reasons behind this transformation, like change in culture, work styles, lifestyles, etc. but the most significant is space availability.

A typical multi-storey house has a floor plate, which has multiple Dwelling Units (DU's). The same configuration of the floor plate is repeated over the floors above it. The structure type is commonly an R.C.C framed in which the walls are Non-Load Bearing functioning merely as partitioning member. The thickness of these Non-Load Bearing partition walls contributes significantly in reduction of Net-Useable area of dwelling unit. It also contributes in the overall dead load of the structure. Thus, this research aims to analyze the configuration of dwelling units (DU's) of different sizes ranging from 1 Bhk to 4 Bhk spread across different regions in India on the above two parameters.

The architectural layout of these DUs has been analyzed in relation to useable and non-useable areas, whose proportion is usually referred to as "Loading". The study revealed that the a) Internal Layout Design, and b) Partitioning Walls are the two main factors responsible for "Loading".

The outcome of this study will provide a baseline to support efficient space planning and decision-making for the designers and developers thus helps them to manage residential spaces more efficiently.

Keywords: *Non-Load Bearing (NLB) walls, Built-Up Area, Dwelling Units (DU's), Dead Load, RERA, Loading.*

1. Introduction

In India, residential housing accounts for almost 80 per cent of the real estate market in terms of volume and has been growing at 30 to 35 per cent annually (KPMG, Cushman and Wakefield, Knight Frank, CRISIL). Growing number of nuclear families, migration of rural population to urban are the two main reasons for this steep growth. As per the figures given by Ministry of Housing and Urban Poverty Alleviation (MoHUPA, 2012) the total housing shortage in India is 18.78 million, out of which 14.99 million dwelling units comprise dilapidated and congested houses. To meet this housing shortage the government had launched Pradhan Mantri Awas Yojna (PMAY) with an aim to provide housing for all till 2022. About 80 per cent of the total housing to be built under (PMAY) involves urban renewal, upgradation, regularization, redevelopment, rehabilitation and retrofitting.

Affordable housing has been largely the domain and responsibility of the Government. However, in the recent years, private developers have started exploring the opportunity to cater to this segment. One of the main hurdles in the growth of affordable housing is non-availability of land and ineffective land management practices (Kundu and Sharma, 2017). According to the Town and Country Planning Organisation (TCPO) to meet the housing shortage in the form of group housing on average density norms, 84,724 Hectares to 1,20,882 Hectares of additional land would be required. Land is the basic platform for housing and other activities. However, the acquisition of private lands has become extremely difficult under the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. Even if the land is acquired, still it is the most expensive component of housing cost (Jain, 2017).

Thus, to make social housing affordable and viable the FAR/FSI have been significantly increased by the development authorities over the past few years which opens the existence of multi-storeyed buildings. The land price plays a major role in pricing and affordability of dwelling units and on an average constitutes 30-50 per cent of the cost of an urban housing project (Chandra, 2017). The price of high-end residential projects is largely guided by land costs, construction costs have a significant share in the price of affordable housing. During the past decade, construction costs have significantly increased due to the appreciation in prices of construction materials (Kundu and Sharma, 2017). In order to minimize the construction cost, the Building Materials and Technology Promotion Council (BMTPC) developed several innovative affordable housing technologies but facing various challenges in upscaling.

Due to the presence of private developers in the market, the homebuyers were facing various issues like timely possession of purchased unit, Construction Quality, Area of the DU, etc. Thus, to safeguard the interests of homebuyers the government enacted the Real Estate (Regulation and Development) Act, 2016 and created a Real Estate Regulatory Authority and Appellate Tribunal that will act as the watchdogs for the housing sector. The Act requires greater disclosure from the developer, accountability and removing the information asymmetries from the housing market. A major provision of the Act is the standardisation of area measurement, with carpet area to be the measure. In the real estate market, Built Up Area, Carpet Area and the Super Built Up Area are the three terms widely used amongst Developers and Buyers. After the implementation of RERA in, 2016, the definition of "Carpet Area" is slightly altered as 'the net usable floor area of an apartment, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah area and exclusive open terrace area, but includes the area covered by the internal partition walls of the apartment'. The "Built Up Area" includes the carpet area and the area occupied by the external walls, columns, ducts and, balconies of the dwelling unit (DU) and the "Super Built Up Area" also called as "Saleable Area" is the sum of the built-up area and common spaces which include the DU's proportionate share of the lobby, common staircase and lift, the corridor outside the DU.

Typically, before implementation of RERA, selling apartments based on super built up area was the usual practice by most of the developers. Due to this practice, the homebuyers were ended up paying a hefty amount without even knowing the exact usable area (Carpet Area). Carpet area is usually 25–35% lower than the super built up area. For instance, if an apartment is said to be the size of 2,000 sq. ft, the actual usable area, or the carpet area, will be 1,400–1,500 sq. ft.

However, after implementation of RERA the developers are bound to sell units on carpet area but still from the buyer's perspective the percentage of net usable area or carpet area may vary due to the layout design and internal partitioning walls. Apart from the buyer's problems, the builders also face many difficulties. Thus, the Act has defined a set of stringent norms for the real estate developer, the intermediary as well as the consumer, to encourage healthy and just relationships between the parties involved. From the developer's perspective, the focus is always on to minimize the overall project cost which can only be achieved by either reduction in land cost or construction cost or both. Out of land cost and construction cost, it is only the later one which a developer can control because the former comes directly under the purview of government.

Thus, the aim of this paper is to analyse the layouts of various configurations of dwelling units with respect to Built-up Area and Net Usable Area or Carpet Area, then quantify the contribution of walls (Non-Load Bearing Partitions) in Dead Load of the structure.

2. Background & Literature Review:

Housing is a key component in the sustainable development of a community (Dumreicher and Kolb, 2008). Economic, environmental, and social are the three terms associated with sustainable development (Keiner, 2005).

Various studies are available in the literature, concerning the selection of construction technologies, materials, partition members etc. based on Embodied Energy and Carbon Emissions, some of which are indicatively referred herein. (Venkatarama et al.), estimated the energy consumed for the production, transportation and installation on-site of several traditional construction materials and concluded that an important amount of energy is spent for their manufacture and transportation. (Shams et al.) focused on a typical, five-floor residence in Bangladesh and examined the associated carbon emissions for different construction materials. (Wallbaum et al., 2012) suggests the most promising technologies for affordable housing based on sustainability indicators.

Embodied Energy and Carbon emissions are defined as the Energy requirements for production and processing of different building materials and the Carbon emissions and the implications on the environment (Buchanan and Honey, Suzki et al, Oka et al., Debnath et al., Reddy and Jagadish). In order to estimate the total embodied energy and the related carbon emissions of a building, a good material analysis, i.e. breakdown of the various building components to their constitutive materials is required. However, respective material quantities also have significant role in quantification of Embodied Energy and Carbon Emissions.

Various researchers suggest alternative materials in order to reduce the EE and carbon emissions but none of them focussed on reducing the material quantities itself. Debnath et al. estimated the energy requirement for different types of residential buildings in India and concluded that the bricks, cement and steel are the three major contributors to energy cost of building construction. In multi-storeyed buildings the cement and steel are majorly used in structural members i.e. column, beam, slab, foundation and bricks are used primarily as partition members which unnecessary add load to the structural members. Thus, this paper aims to investigate the contribution of different types of partitioning members on the dead load of the structure.

3. Methodology

A two-step process analysis was implemented, the first one focusses on analysis of useable and non-useable area and the second one focusses on dead load calculations. In the first step the layout plans of dwelling units having four different configurations i.e. 1 Bhk, 2Bhk, 3Bhk and 4 Bhk were analysed to calculate the percentage of wall area. Four cases in each configuration were selected based on different partitioning members, makes overall 16 cases. In the second step the dead load of partitioning members was calculated after multiplying the density of respective material with its calculated volume.

4. Scope and Limitations

In this study the calculations were based only on the four types of partitioning members i.e. Clay Brick Wall, AAC Blocks, Fly Ash Brick Wall, RCC Wall and EPS Core Panel System. The EPS core panel system is being promoted by the Government of India for the affordable housing and thus only be considered for 1 Bhk and 2 Bhk dwelling units due to the non – availability of case studies in 3 bhk and 4 Bhk DU's. The impact of dead load on the structural members is not calculated in this study and can be taken up further.

5. Case Studies

Sixteen case studies of four different configurations ranging from 1Bhk to 4 Bhk were selected. The details of all sixteen cases are presented below in Table 1. All the case studies are live projects registered under RERA and located in multiple locations across India. There is a mix of ongoing, proposed, and operational projects, which makes the huge variation in the selling price. The case studies are divided equally into four groups i.e A, B, C and D based on configuration of DU's.

6. Results and Discussion

For each case study, the value and the percentage contribution of the wall areas (in SqM) are presented in Table 1. Table 3 summarizes the wall area, Dead Load, as well as the dead load intensity values, i.e. values normalized per unit Built Up area.

Table 1 Details of Case Studies

Projects	Config.	Location	BuA (in SqM)	Wall Area (in SqM)	Net Usable Area (in SqM)	Wall Area (%)	Remarks
A.1	1 BHK	Bhubaneswar	28.13	3.35	24.78	12%	150 MM External and Internal EPS Core Panel
A.2	1 BHK	Pune	54.81	10.18	44.63	19%	230 MM External and 115 MM Internal Clay Brick Wall
A.3	1 BHK	Mumbai	49.51	7.4	42.11	15%	150 MM RCC Wall
A.4	1 BHK	Noida	66.96	10.6	56.36	16%	230 MM External and 110 MM Internal Fly Ash Brick Wall
B.1	2 BHK	Jaipur	97.82	20.35	77.47	21%	400 MM External and 200 MM Internal AAC Blocks
B.2	2 BHK	Gurugram	58.06	9.37	48.69	16%	230 MM External and 115 MM Internal Clay Brick Wall
B.3	2 BHK	Lucknow	74.78	7.99	66.79	11%	150 MM External and Internal EPS Core Panel
B.4	2 BHK + Study	Kolkata	139.04	17.29	121.75	12%	150 MM RCC Wall
C.1	3 BHK + Servant	Bengaluru	141.21	23.39	117.82	17%	200 MM External and 100 MM Internal AAC Blocks
C.2	3 BHK	Delhi	110.41	14.81	95.60	13%	150 MM RCC Wall
C.3	3 BHK	Chennai	102.3	19.60	82.7	19%	230 MM External and 115 MM Internal Clay Brick Wall
C.4	3 BHK	Mumbai	84.23	12.43	71.8	15%	230 MM External and 110 MM Internal Fly Ash Brick Wall
D.1	4 BHK	Kolkata	144.38	18.49	125.89	13%	150 MM RCC Wall
D.2	4 BHK + Servant	Bengaluru	187	32.76	154.24	18%	300 MM External and 200 MM Internal AAC Blocks
D.3	4 BHK + Servant	Pune	219.43	33.61	185.82	15%	230 MM External and 115 MM Internal Clay Brick Wall
D.4	4 BHK	Ahmedabad	170.76	27.92	142.84	16%	230 MM External and 110 MM Internal Fly Ash Brick Wall

According to Table 1, the percentage contribution of wall areas is ranging from 11% to 21%, lowest being the EPS core panel system having 150 mm thickness and highest being AAC blocks having thickness of 400 mm due to cavity in the external wall. As evident from the results the configuration and size of DU's doesn't have much impact on the net usable area. Although the thickness of RCC walls and EPS panels are same yet the wall areas ranging from 11 to 15%, this variation is purely due to the design layout. Similar, variation is also observed in the Clay Bricks, Fly Ash and AAC blocks ranging from 15% to 19%. Thus, it is evident that the layout design also contributes significantly in the net usable area. The table 3, calculates the extra amount paid by users for the non-usable area. The table clearly shows the huge variation in the premium paid by the users which is ranging from approximately Rs. 5,000 per sqm to 17,000 per sqm of built up area although it is also depending upon the selling price of the DU.

Table 2 Density of selected partitioning members

S.No.	Partitioning Member	Density (in Kg/M³)
1	150 MM External and Internal EPS Core Panel	1150
2	230 MM External and 115 MM Internal Clay Brick Wall	1665
3	150 MM RCC Wall	2450
4	230 MM External and 110 MM Internal Fly Ash Brick Wall	1350
5	400 MM External and 200 MM Internal AAC Blocks	825

The densities of selected partitioning members considered are summarized in Table 2. The density of EPS core panel system is calculated considering 80 mm thickness of EPS panel having density of 15 Kg/CuM, 35 mm thickness of concreting on both sides having density of 2400 Kg/CuM and steel mesh having density of 8500 Kg/CuM. Thus, the overall density calculated for EPS core Panel system is 1150 Kg/CuM. Similarly, the density of clay brick wall, fly ash brick wall, AAC blocks and R.C.C. walls were calculated as 1665 Kg/CuM, 1350 Kg/CuM, 825 Kg/CuM and 2450 Kg/CuM. The volume of the partitioning members was calculated considering the average height of the partition walls 3 M. The densities were multiplied with volume of the respective partitioning members to give overall dead load of the partitioning members. The overall dead load calculated was then divided by the built-up area to provide the dead load intensity per SqM. It is evident from the results that, despite having minimum density of AAC blocks among all, its contribution in dead load of the structure is at par with that of EPS core panel system due to the later one having lesser volume. Considering contribution in Built Up Area and Dead Load together the EPS core panel system performs well while comparing with other partitioning members.

Table 3 Summary of Results

Projects	Config.	BuA (in SqM)	Wall Area (in SqM)	Wall Area (%)	Selling Price (Rs/SqM)	Dead Load on Slab (Kg/SqM)	Amount paid by user per SqM for Non-Usable Area (in Rs.)
A.1	1 BHK	28.13	3.35	12%	₹ 43,000	411	₹ 5,121
A.2	1 BHK	54.81	10.18	19%	₹ 82,000	928	₹ 15,230
A.3	1 BHK	49.51	7.4	15%	₹ 95,000	1099	₹ 14,199
A.4	1 BHK	66.96	10.6	16%	₹ 60,000	641	₹ 9,498
B.1	2 BHK	97.82	20.35	21%	₹ 48,000	515	₹ 9,986
B.2	2 BHK	58.06	9.37	16%	₹ 72,000	806	₹ 11,620
B.3	2 BHK	74.78	7.99	11%	₹ 58,000	369	₹ 6,197
B.4	2 BHK + Study	139.04	17.29	12%	₹ 64,000	914	₹ 7,959
C.1	3 BHK + Servant	141.21	23.39	17%	₹ 84,000	410	₹ 13,914
C.2	3 BHK	110.41	14.81	13%	₹ 76,000	986	₹ 10,194

C.3	3 BHK	102.3	19.60	19%	₹ 81,000	957	₹ 15,519
C.4	3 BHK	84.23	12.43	15%	₹ 90,000	598	₹ 13,281
D.1	4 BHK	144.38	18.49	13%	₹ 74,000	941	₹ 9,477
D.2	4 BHK + Servant	187	32.76	18%	₹ 96,000	434	₹ 16,818
D.3	4 BHK + Servant	219.43	33.61	15%	₹ 88,000	765	₹ 13,479
D.4	4 BHK	170.76	27.92	16%	₹ 66,000	662	₹ 10,791

7. Conclusion:

The thorough analysis clearly indicates that the NLB partitions have significantly contributes in both Built up Area and Dead Load of the structure. This impacted both buyers as well as developers. On one side where buyers have to pay extra money for Non-Usable area, on the other side the additional dead load resulting in larger sizes of structural members thus impacting higher construction cost for the developers. Apart from impacting financially, selecting appropriate NLB partition may also reduce the embodied energy and carbon emissions of the building. A wholesome effort is needed incorporating the attributes like net usable area and dead load along with embodied energy and carbon emissions while selecting the NLB partitions.

The results obtained from the analysis provided valuable information for consultants and developers to support strategic planning and decision-making at the project initiation phase and thus help them to reduce the construction cost, environmental impacts and provide space efficient layouts to their customers.

Accordingly, it is suggested that the cost of impact of dead load on structural members can be carried out separately. An analysis to study the effect of NLB partitions on the structural performance of various comparative case studies might reveal more detailed results.

8. References

Afairs MOHAU (2017). *Pradhan Mantri Awas Yojana-Housing for All (Urban).* http://mohua.gov.in/cms/about-pmay.php. Accessed on 16 Aug 2019.

Buchanan, A. H., & Honey, B. G. (1994). *Energy and carbon dioxide implications of building construction.* Energy and Buildings, 20(3), 205-217.

Chandra, T. *Affordable urban housing: A way forward.* NCHF BULLETIN, 17.

CRISIL, 2006. *Demand Fundamentals Support Mortgage Asset Quality.* CRISIL Insight.

CRISIL, n.d. KPMG Cushman & Wakefield, Knight Frank. [Online] Available at: http://sezindia.com

Debnath, A., Singh, S. V., & Singh, Y. P. (1995). *Comparative assessment of energy requirements for different types of residential buildings in India.* Energy and buildings, 23(2), 141-146.

Dumreicher, H., & Kolb, B. (2008). *Place as a social space: Fields of encounter relating to the local sustainability process.* Journal of environmental management, 87(2), 317-328.

Hammond, G. P., & Craig, I. J. (2010). *Inventory of Carbon and Energy (ICE),* Sustainable Energy Research Team (SERT), University of Bath, 2006. Retrieved June 10.

Jain, A. K. *Rethinking the Pradhan Mantri Awaas Yojana.* NCHF BULLETIN, 10.

Keiner, M. (2005). *History, definition (s) and models of sustainable development.* ETH Zurich.

Keskar, Y. M., Choudhury, B., & Mandal, N. R. (2018). *Critical Evaluation of Housing Scenario in India.*

Kundu, D., & Sharma, P. *Affordable Housing: issues and Way forward.* NCHF BULLETIN, 21.

Monahan, J., & Powell, J. C. (2011). *An embodied carbon and energy analysis of modern methods of construction in housing: A case study using a lifecycle assessment framework.* Energy and Buildings, 43(1), 179-188.

Reddy, B. V., & Jagadish, K. S. (2003). *Embodied energy of common and alternative building materials and technologies.* Energy and buildings, 35(2), 129-137.

Rohilla, S. (2019). *Plight of Buyers and Consumers and Respite under the Real Estate (Regulation and Development Act 2016)*. National Journal of Real Estate Law, 1(1), 24-32.
Shams, S., Mahmud, K., & Al-Amin, M. (2011). *A comparative analysis of building materials for sustainable construction with emphasis on CO2 reduction*. International Journal of Environment and Sustainable Development, 10(4), 364-374.
Suzuki, M., Oka, T., & Okada, K. (1995). *The estimation of energy consumption and CO2 emission due to housing construction in Japan*. Energy and Buildings, 22(2), 165-169.
Syngros, G., Balaras, C. A., & Koubogiannis, D. G. (2017). *Embodied CO2 emissions in building construction materials of Hellenic dwellings*. Procedia environmental sciences, 38, 500-508.
Wallbaum, H., Ostermeyer, Y., Salzer, C., & Escamilla, E. Z. (2012). *Indicator based sustainability assessment tool for affordable housing construction technologies*. Ecological Indicators, 18, 353-364.
Xing, S., Xu, Z., & Jun, G. (2008). *Inventory analysis of LCA on steel-and concrete-construction office buildings*. Energy and Buildings, 40(7), 1188-1193.